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On Comparing Groups of Fishes Based on Length-Weight Relationships

CHARLES W. CAILLOUET, JR.

Abstract

F. Torres, Jr., in a 1991 *Fishbyte* article, presented length-weight relationships derived from 122 graphs in van der Elst's *1981 A guide to the common sea fishes of southern Africa*. This author analyzes Torres's tabulated results to determine whether or not *a*, *b*, lna, L_{max} and $\ln L_{max}$ were correlated. Highly significant ($P < 0.01$) negative correlations between *b* and lna ($r = -0.868$) and between lna and $\ln L_{max}$ ($r = -0.276$) were detected. Thus, Torres's mean of *b* for this sample of 122 species may have been influenced not only by the species composition of the sample, but also by the range in size of individuals of each species.

Introduction

For each of 122 species from 93 genera and 44 families of marine fishes, Torres (1991) extracted four weight (W, in kg) and length (L, in cm) data pairs from L-W graphs presented by van der Elst (1981). Using least-squares regression, of the form $\log_{10}W = \log_{10}a + b\log_{10}L$, to fit the L-W relationship, Torres (1991) estimated b and a for each species, then tabulated these estimates along with the maximum size (L_{max}, in cm) of each species. He conducted a Student's t-test to compare the mean $\bar{b} = 2.88$, of this sample of 122 species with 3, the average *b* reported for different multispecies samples of fishes by Carlander (1969) and Cinco (1982). Coincidentally, 3 also is the expected value of *b* when growth in W and L is isometric (Beyer 1987; Cone 1989; Beyer 1991).

Using Torres's (1991) tabulated results for his 122-species sample of marine fishes, I examined the frequency distributions of *b*, *a*, lna, L_{max} and $\ln L_{max}$, to determine which if any were normal. I then examined all possible bivariate, product-moment correlations among *b*, *a*, lna, L_{max} and $\ln L_{max}$ to determine if any were significant.

Materials and Methods

I extracted *b*, *a* and L_{max} data for each of the 122 species of marine fishes from Torres's (1991) tabulation, and conducted univariate analyses of *b*, *a*, lna, L_{max} and $\ln L_{max}$. I then conducted product-moment correlation analyses to examine all bivariate relationships among b, a, lna, L_{max} and $\ln L_{max}$.

Results and Discussion

Descriptive statistics for *b*, *a*, lna, L_{max} and $\ln L_{max}$ are presented in Table 1. The distributions of b, lna and $\ln L_{max}$ were normal, as indicated by high values of the Shapiro-Wilk statistic (Shapiro and Wilk 1965), *W*, and skewness and kurtosis coefficients approaching 0, but the distributions of

Table 1. Descriptive statistics for b, a, ln$a$, L_{max} and lnL_{max}.[a]

	b	a	ln$a$	L_{max}	lnL_{max}
Mean	2.877	4.873×10^{-5}	-11.010	129.3	4.568
Standard Deviation	0.302	1.227×10^{-4}	1.505	119.8	0.740
Skewness coefficient	-0.465	6.438	-0.312	2.651	0.390
Kurtosis coefficient	1.700	48.100	0.729	8.805	-0.068
Minimum	1.88	2.16×10^{-7}	-15.35	20	3.00
Maximum	3.84	1.09×10^{-3}	-6.82	740	6.61
Shapiro-Wilk[b] W	0.975	0.375	0.976	0.722	0.968
Prob. of a smaller W	0.259	0.0	0.275	0.0	0.065

[a]Based on data from Torres (1991). Sample size n = 122 species.
[b]Shapiro and Wilk (1965). Small values of W lead to rejection of the null hypothesis of normality.

Table 2. Product moment correlation statistics for b, a, ln$a$, L_{max} and lnL_{max}.[a]

	Correlation coefficient, r	P[b]
b vs a	-0.653	0.0001
b vs ln$a$	-0.868	0.0001
b vs L_{max}	0.160	0.0789
b vs lnL_{max}	0.106	0.2446
a vs L_{max}	0.008	0.9285
a vs lnL_{max}	-0.011	0.9069
ln$a$ vs L_{max}	-0.313	0.0004
ln$a$ vs lnL_{max}	-0.276	0.0021

[a]Based on data from Torres (1991). Sample size n = 122 species. Correlations between L_{max} and lnL_{max} and between a and ln$a$ were highly significant ($P < 0.01$), but were not meaningful.
[b]Probability of a greater |r| due to chance alone, under the null hypothesis that r = 0.

a and L_{max} were not normal. Torres (1991) also showed that the distribution of b was normal for this 122-species sample. However, Torres (1991) found that the mean of b, 2.88, was significantly lower ($P = 0.01$) than a mean b of 3, reported for other multispecies samples of fishes by Carlander (1969) and Cinco (1982).

I detected highly significant ($P < 0.01$) negative correlations between b and a, b and ln$a$, ln$a$ and L_{max}, and ln$a$ and lnL_{max} (Table 2). The correlation, r = -0.868, between b and ln$a$ was very strong (Fig. 1). However, the correlation, r = -0.276, between ln$a$ and L_{max} was not very strong, though highly significant. There were no significant ($P > 0.05$) correlations between b and L_{max}, b and lnL_{max}, a and L_{max}, or a and lnL_{max}. In the strictest sense, only those correlations for which both variates were normally distributed (i.e., those for b *vs* ln$a$, ln$a$ *vs* lnL_{max}, and b *vs* lnL_{max}) should be considered valid.

The very strong and highly significant correlation between b and ln$a$, and the weaker, but highly significant correlation between ln$a$ and lnL_{max}, suggest that Torres's (1991) mean of b for this 122-species group of fishes, and his comparison of this mean with 3 (Carlander 1969; Cinco 1982), may have been influenced by variations in ln$a$ which in turn may have been influenced by variations in the maximum size of individuals of each species. I suspect that such relationships exist for other multispecies groups.

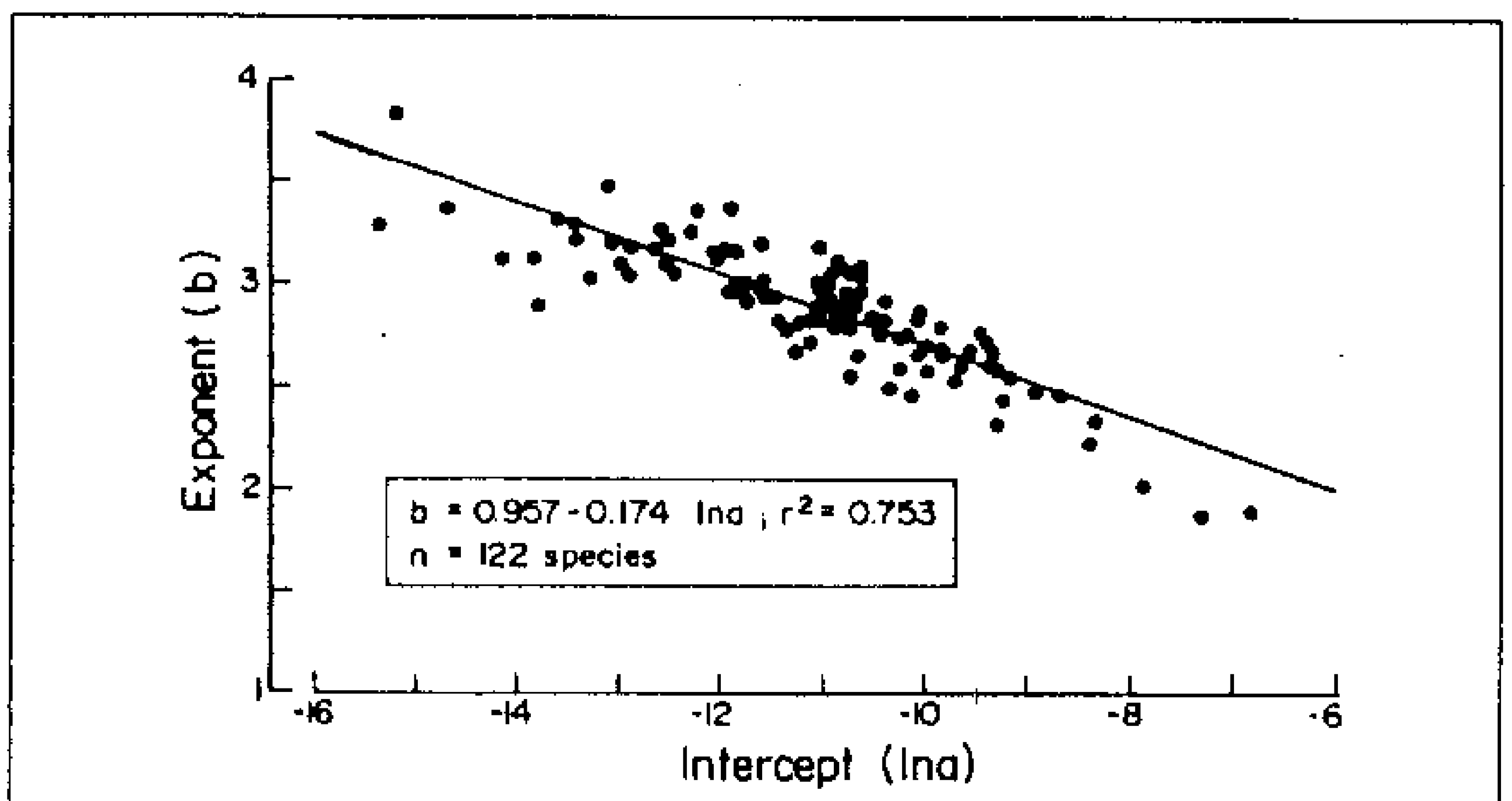

Fig. 1. ***Scatter plot, linear regression equation and coefficient of determination (r^2) for the relationship between b and lna, based on data from Torres (1991).***

Not only is L_{max} (and therefore lnL_{max}) species-dependent, but it also could be study-dependent, because different investigators may not have access to the same range of W and L pairs for a given species, or to the entire range that is characteristic of the species. Because least-squares regression is greatly influenced by extreme observations in the sample, adding a few larger fish could strongly affect the regression results. This problem could be avoided by limiting the regression for each species to a similar range of sizes. Comparisons of W-L relationships among different temporal-spatial groupings of individuals of the same species are affected similarly (Cone 1989).

Investigators might capitalize on the strong relationship between b and ln$a$. Perhaps both b and ln$a$ should be incorporated, for example through covariance analysis based on linear regressions of b on ln$a$, in comparing multispecies samples of fishes from different studies, or in conducting interspecific comparisons using samples of individuals of the same species from different temporal-spatial groupings.

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